Lithium Ion Medium Power Battery Design

By:

Jeremy Karrick

Charlie Lau

Advisor:

Dr. Brian D. Huggins

Bradley University

December 08, 2009

Outline

- Project Summary
- Project Goals
- Functional Description
- System Block Diagram
- Battery Pack Structure
- Functional Requirements & Specifications
- Standards
- References
- Equipment and Parts List
- Schedule
- Questions

Project Summary

- Objective: Implement Lithium Ion Battery Pack designed for medium power, low carbon footprint applications
- Medium power => 1000 W for 1 hour
- Battery module will be light weight
- Rechargeable via photovoltaic array or wind turbine
- Integrate USB interface for performance analysis

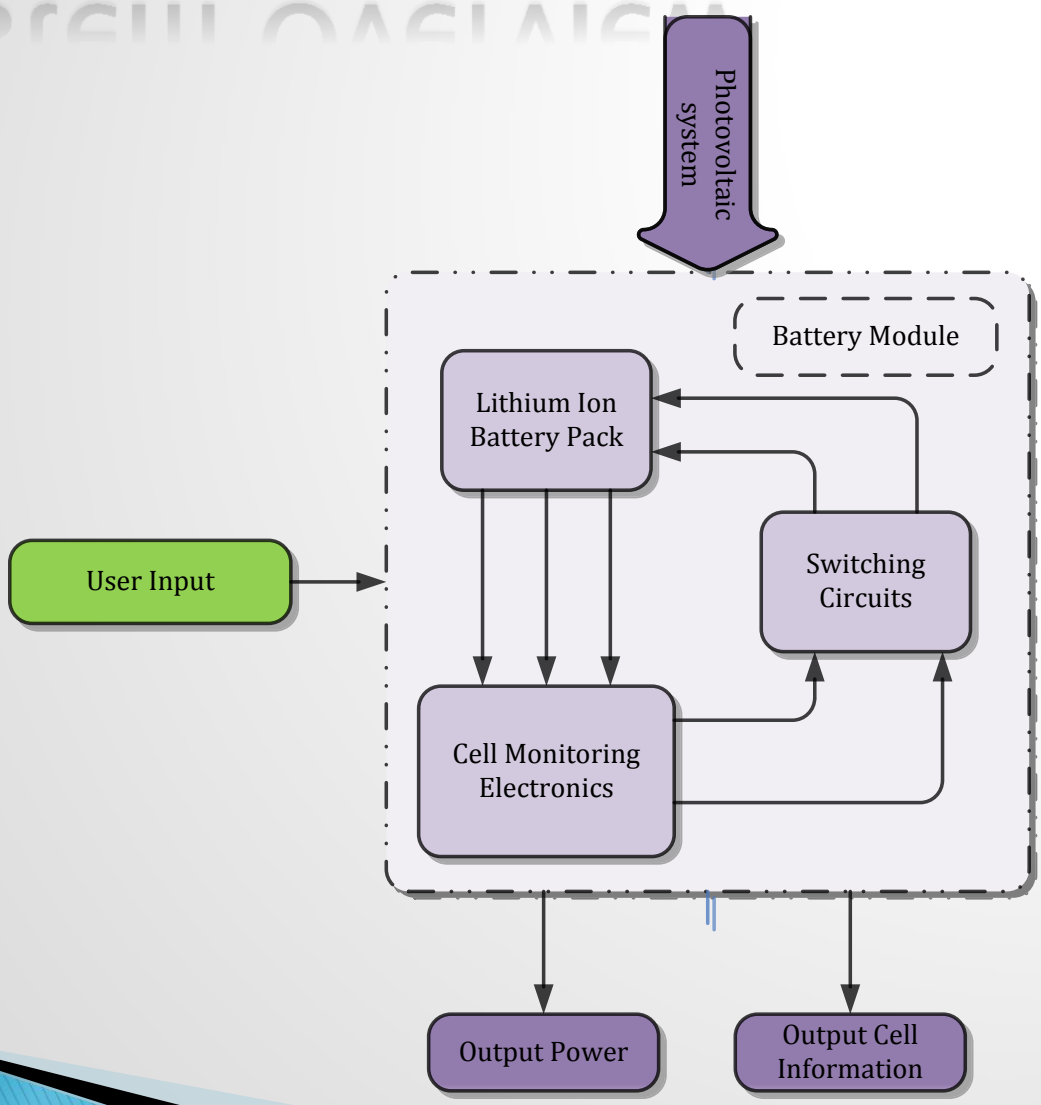
Project Goals

- Develop effective cell layout interconnection and packaging to yield compact medium power battery with appropriate capacity (1000W for an hour)
- Incorporate a battery management subsystem to:
  - Accurately monitor state of cells during charging and discharging
  - Output data, in various formats, on state of cells
  - Ensure soft failure mode in the event of cell degradation
  - Accept user input as needed
- Implement photovoltaic charging system
- Ensure overall design is in compliance with industry standards

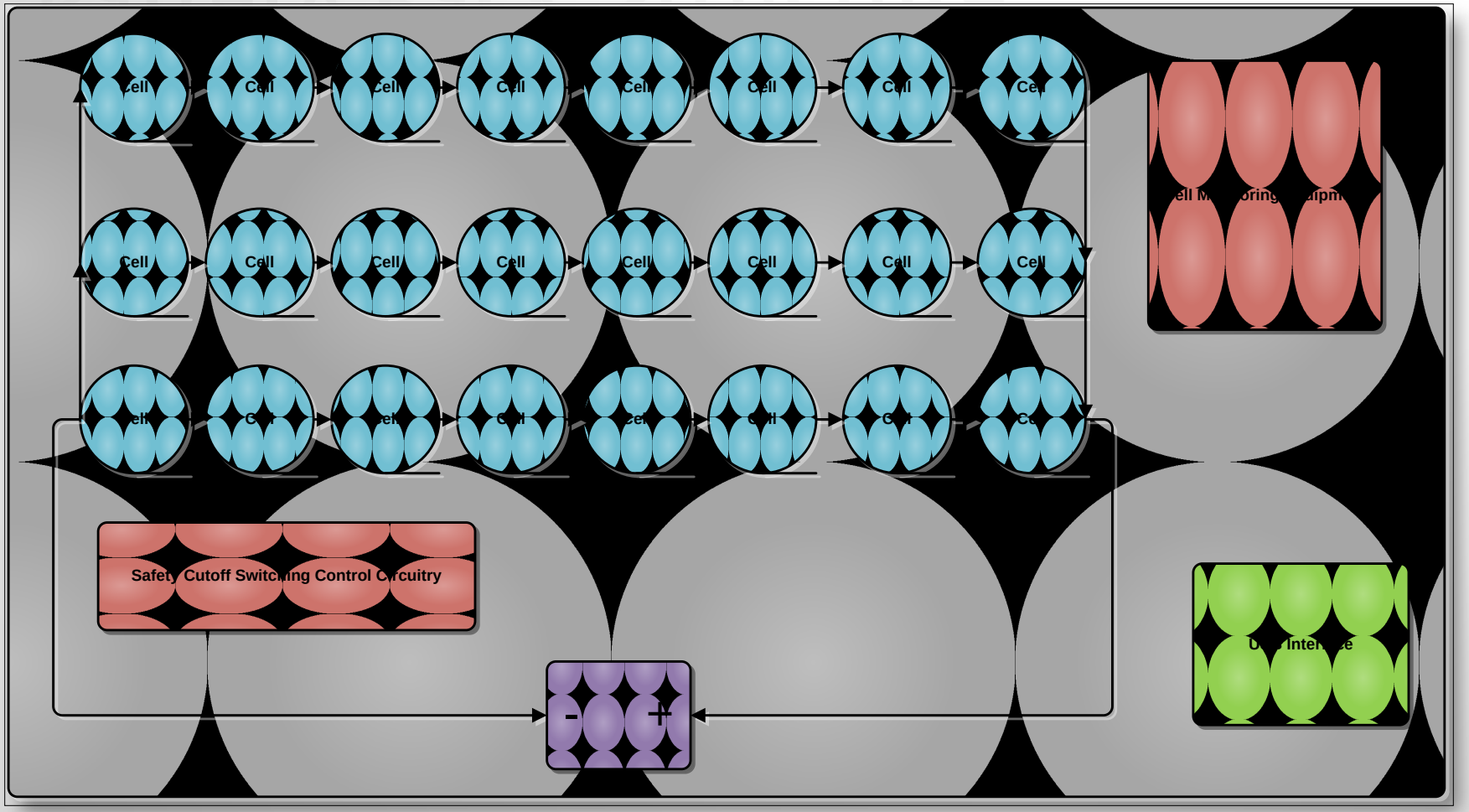
Functional Description

- Block Diagrams
- Structure of battery pack
- Battery monitoring system
- Cell balancing circuitry
- Solar charging source

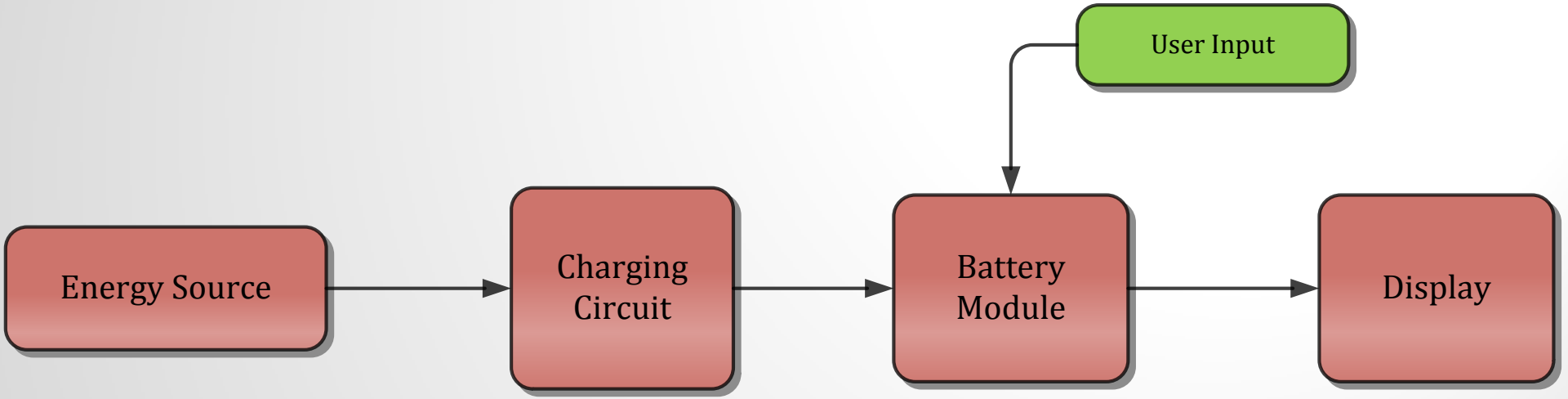
System Overview



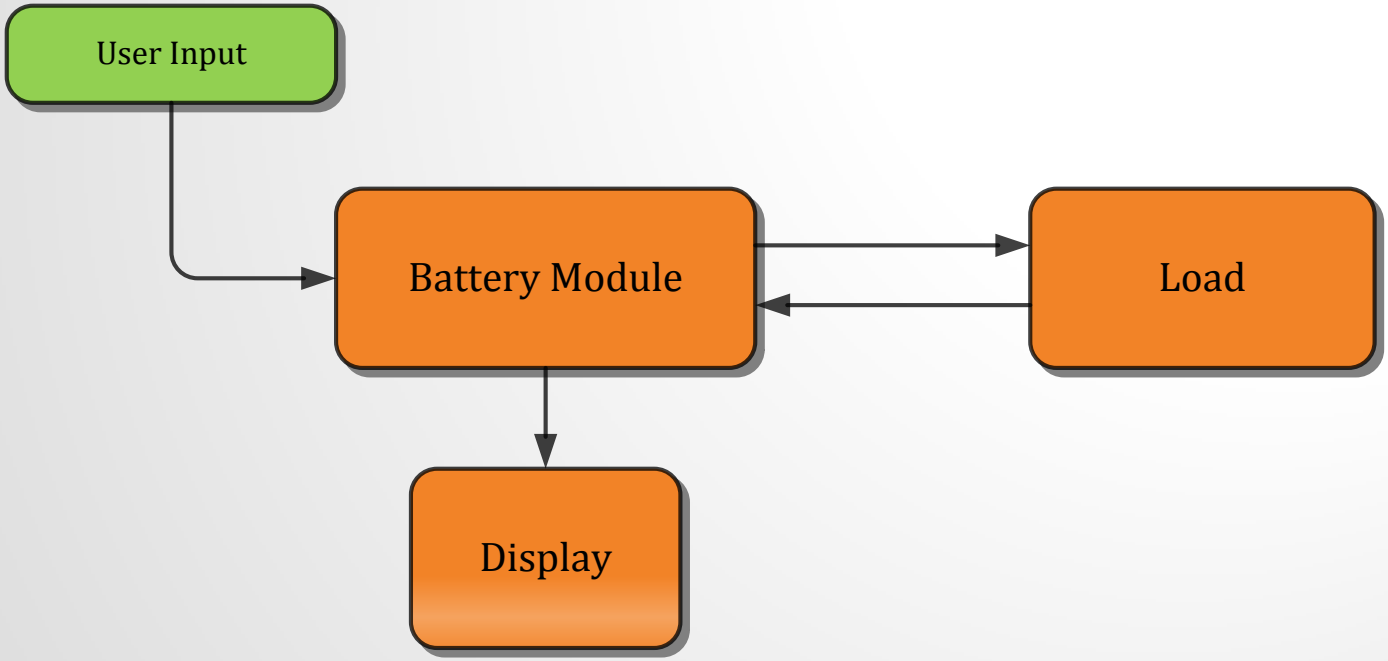
Battery Pack Structure



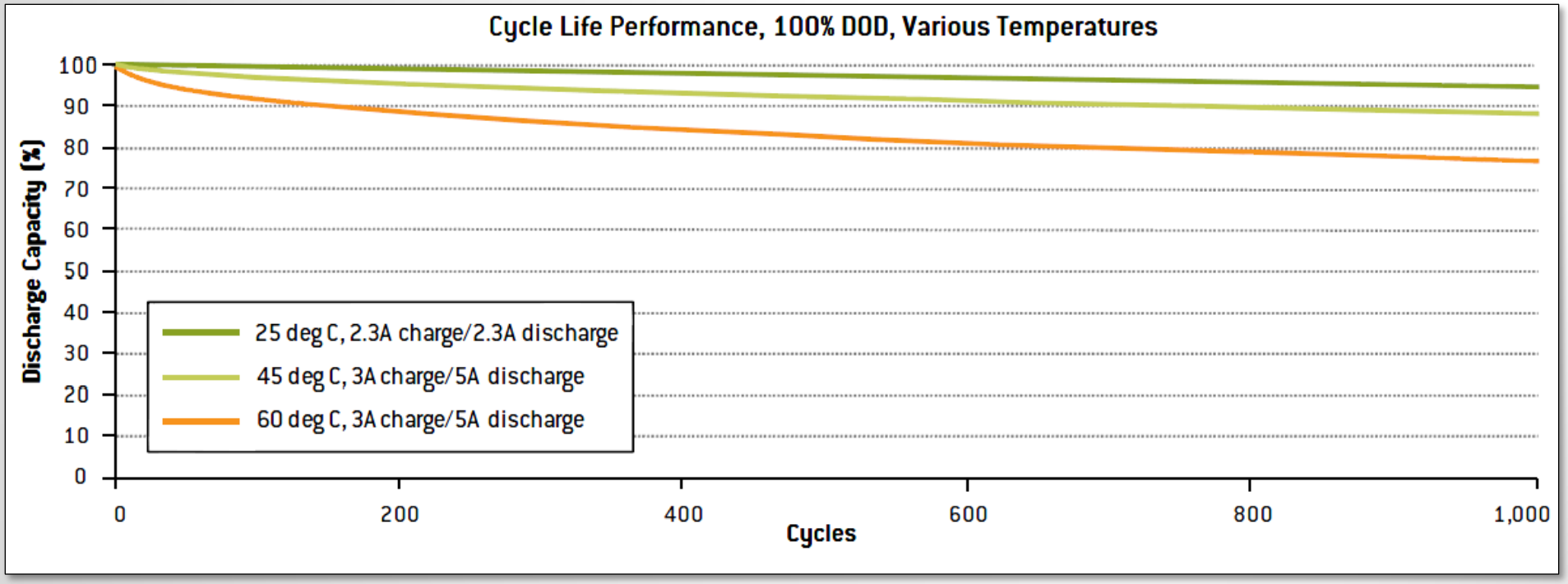
Charging System



Discharging System



Capacity / Cycles

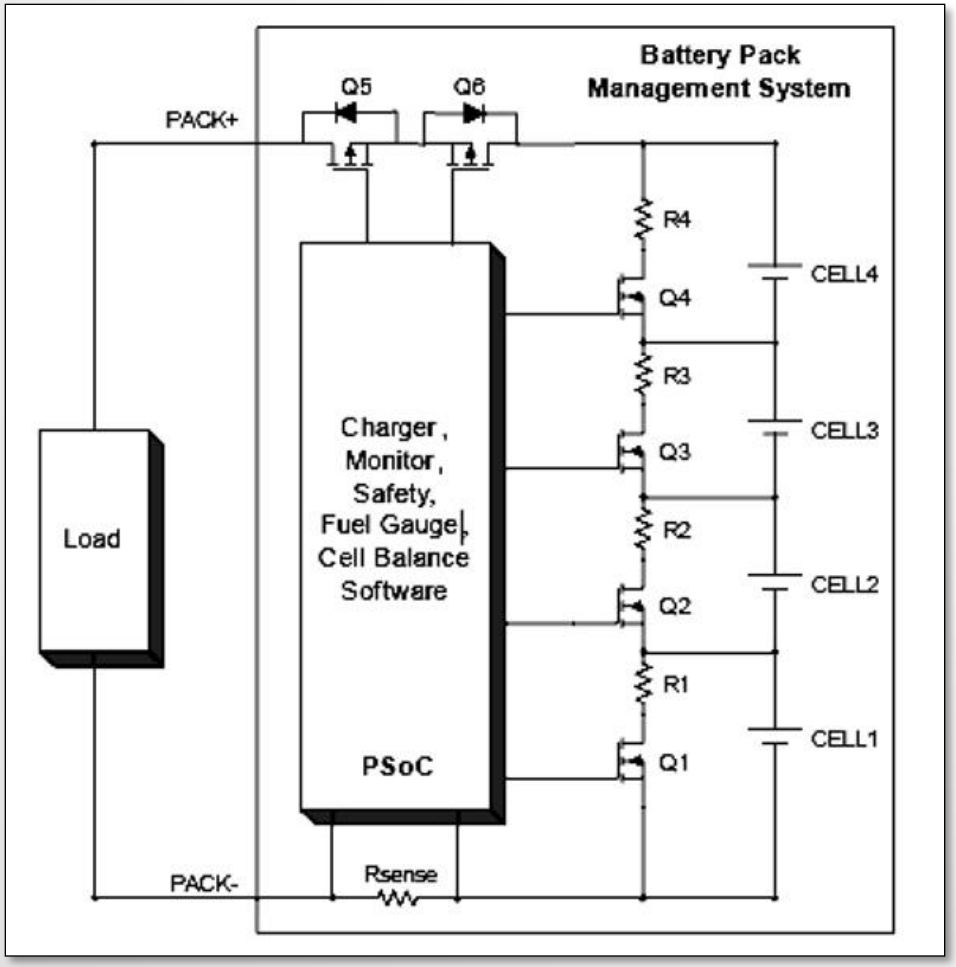


[2]

Battery Monitoring

- Voltage sensors on each battery cell
- Measure current input/output
- Temperature sensor on each cell
- Time for discharge/charging
- Overall Capacity of the battery

Battery Management System Example



[3]

Cell Balancing

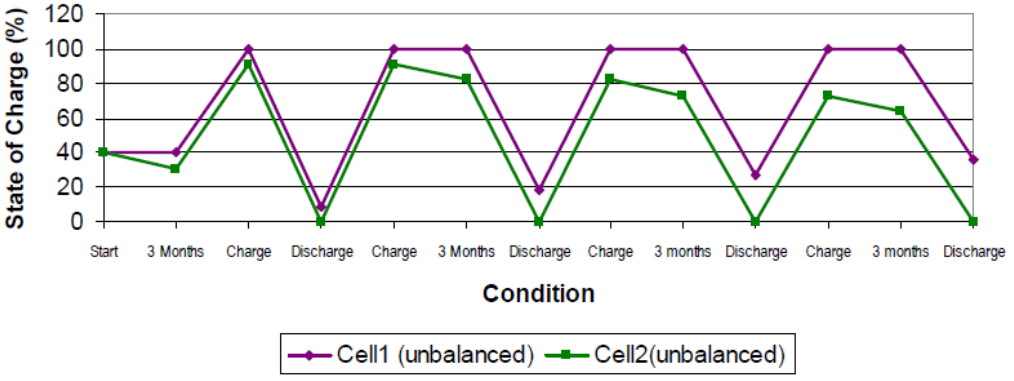


Fig. 1: Cell Capacity With No Cell Balancing

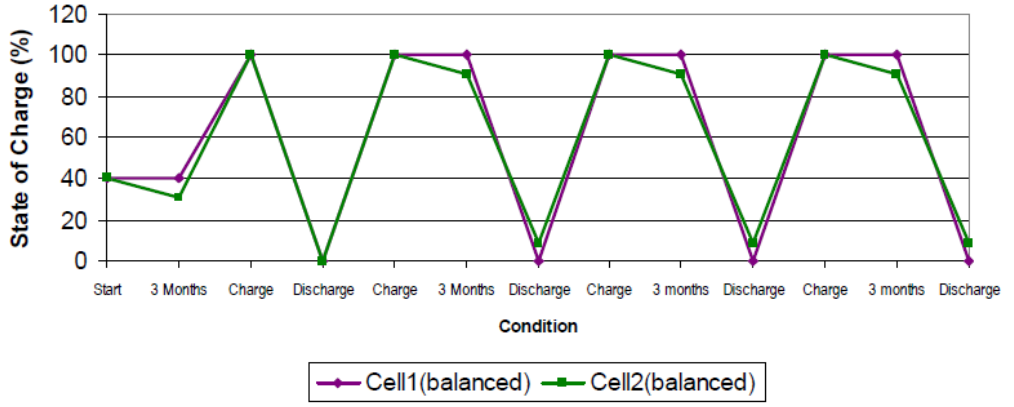
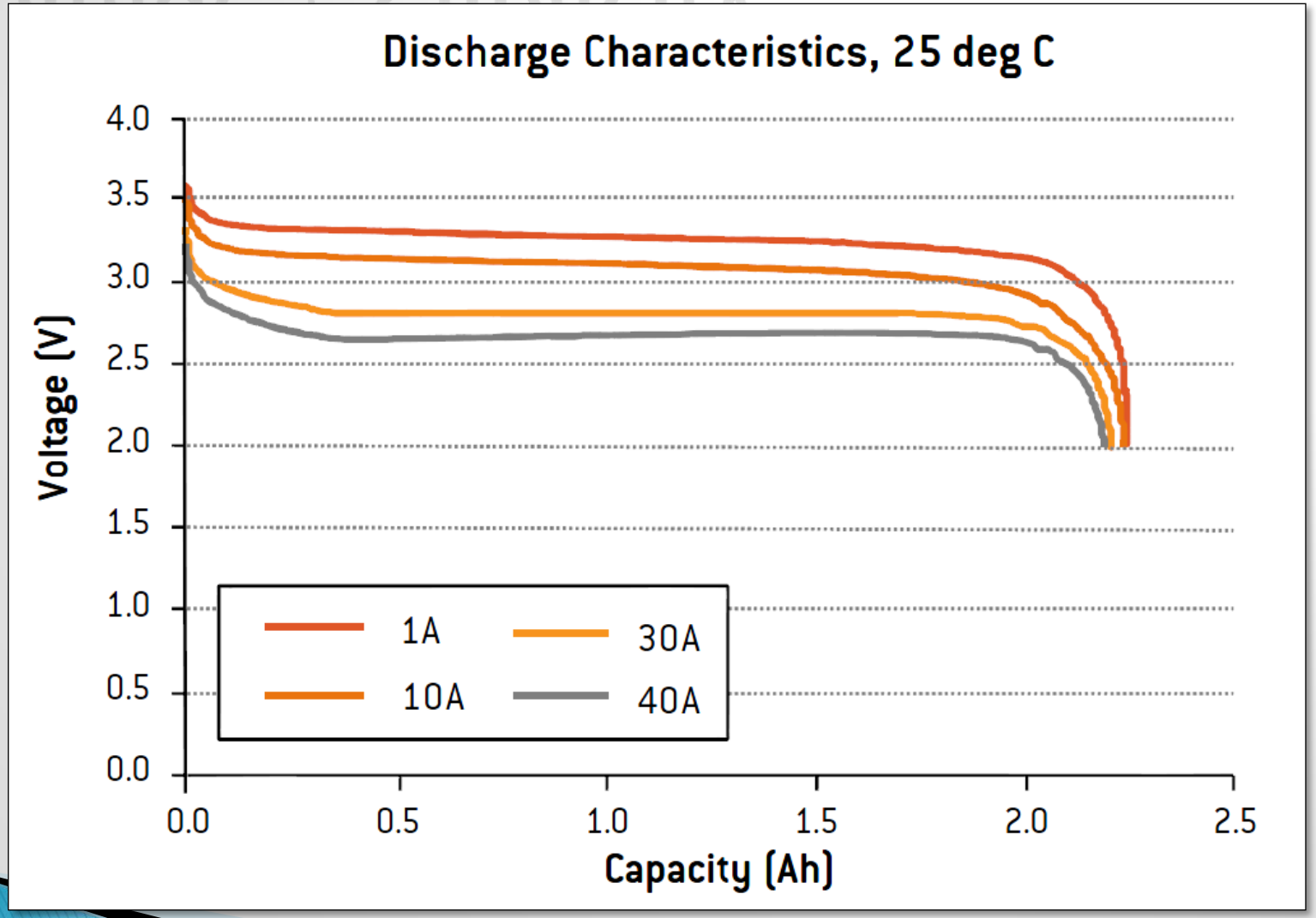


Fig. 2: Cell Capacity With Cell Balancing

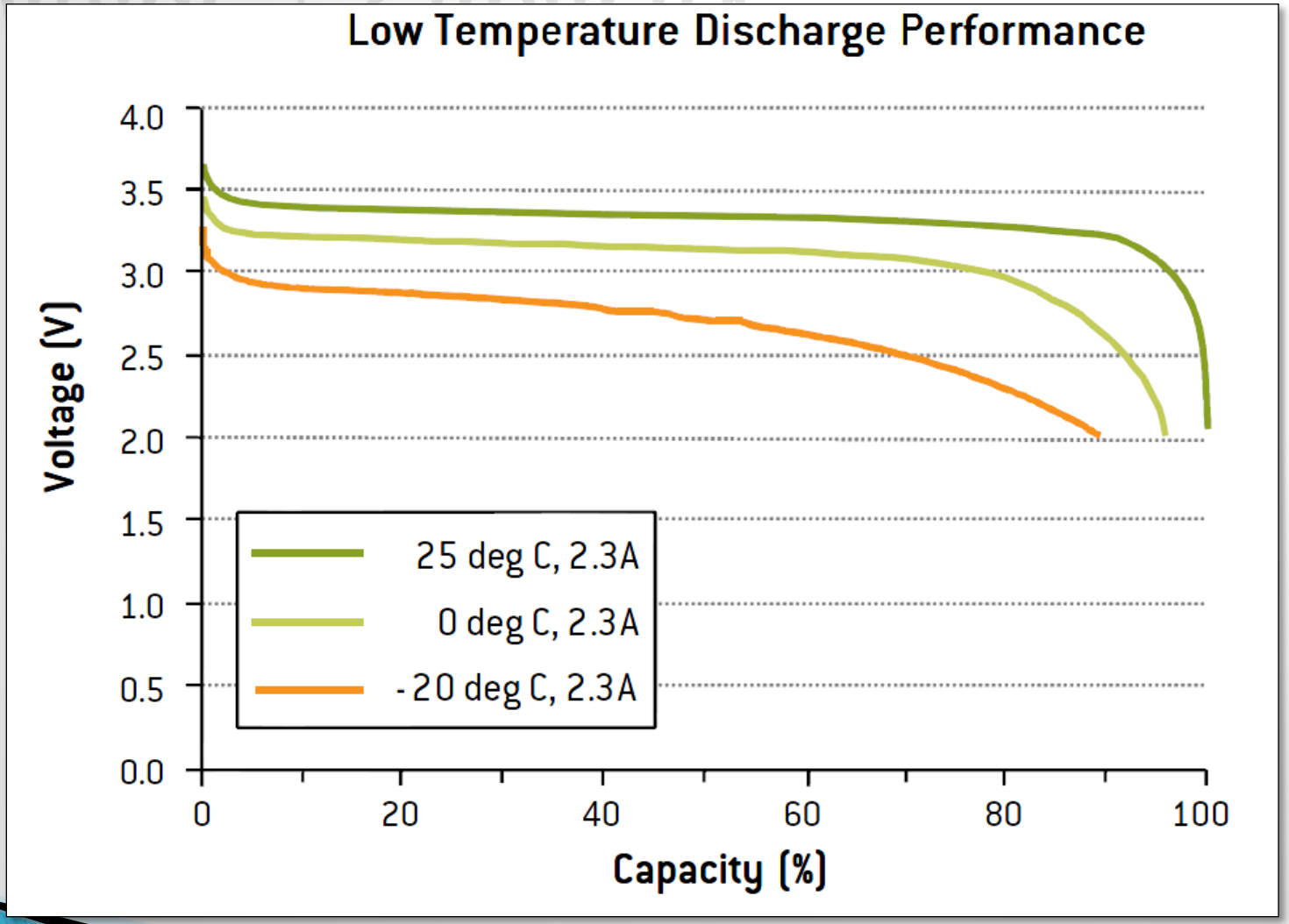
[5]

Voltage / Capacity



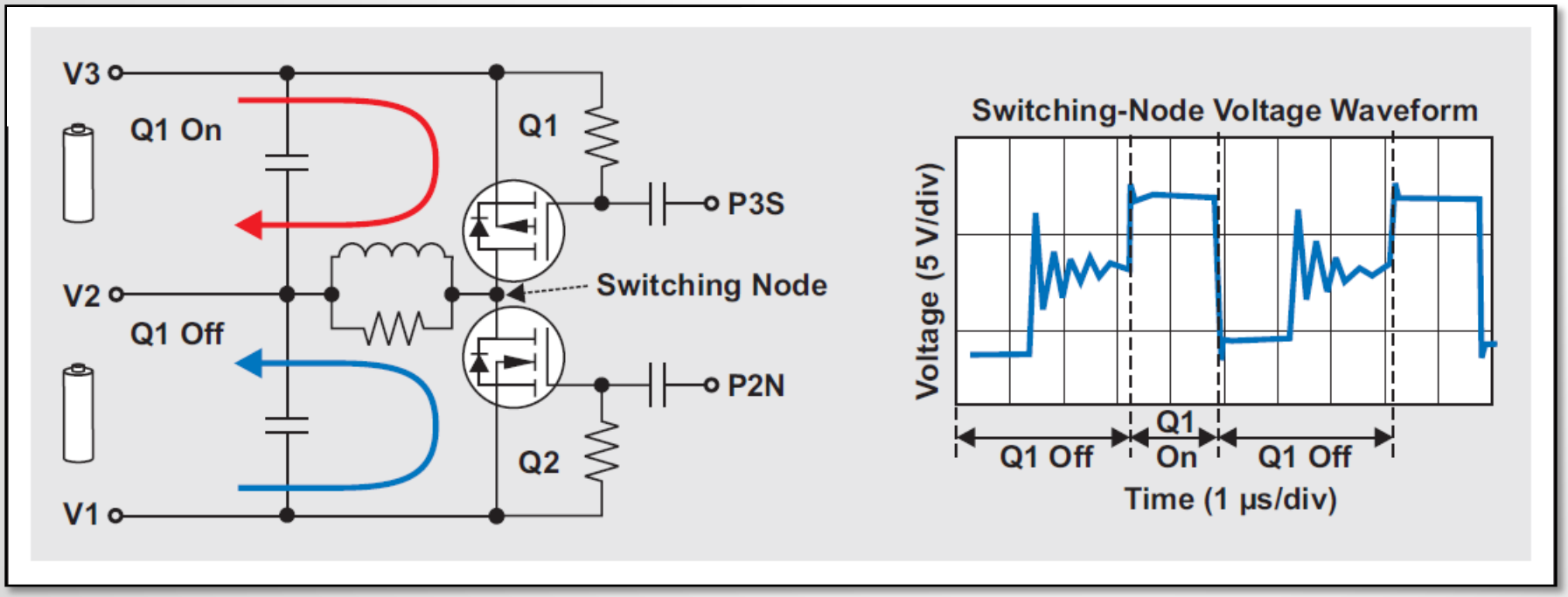
[2]

Voltage / Capacity



[2]

Active Balancing



[4]

Functional Requirements & Specifications

- Nominal capacity => 60 Ah
- Weight => ≤ 13.6 Kg
- Dimensions of module => 50x50x25 cm
- Battery power interface => Threaded Posts
- Battery max discharge => 120 A < 10 sec
- Operational temperature range => -20°C~60°C
- Battery Life => 1000 charge/discharge cycles
- PC interface => USB [Universal Serial Bus]
- Protection Temperature cut-off => 94°C
- Nominal Voltage => 26.4 V [total battery pack]
- Voltage limit => 2.8 V ~ 3.5 V [individual cell]

Standards

- Underwriters Laboratories Standards
  - 1642 – Covers requirements for safety in operation and testing pertaining to Lithium ion rechargeable multi-cell batteries
  - 2054 – Covers requirements for safety in operation and testing pertaining to household and commercial batteries in regards to preventing fires and explosions
- SAE International Standards
  - AS5679 – Lithium-Ion Batteries, Minimum Performance Standards
- IEEE Standards
  - As of 2008 a standard for the characterization of lithium battery technologies in terms of performance, service life and safety attributes is still under development by IEEE

References

- [1] Buchmann, Isidor. Learning the Basics About Batteries. 2003. 10 2009 <http://batteryuniversity.com/>.
- [2] "High Power Lithium Ion ANR26650M1A." 1 4 2009. a123 Systems. 10 2009 <http://a123systems.textdriven.com/product/pdf/1/ANR26650M1A_Datasheet_APRIL_2009.pdf>.
- [3] Multi-cell Li-Ion polymer Battery Charger with Fuel Gauge. 10 2009. 12 2009 <https://secure.cypress.com/?id=1021&rtID=201&rID=23&cache=0>.
- [4] Wen, Sihua. "Cell Balancing Buys Extra Run Time and Battery Life." 17 3 2009. Texas Instruments, Incorporated. 12 2009 <http://focus.ti.com.cn/cn/lit/an/slyt322/slyt322.pdf>.
- [5] Martinez, Carlos. “Cell Balancing Maximizes the Capacity of Multi-Cell Li-Ion Battery Packs.” 2005. Analog Zone. 2009 <http://www.analogzone.com/pwrt0207.pdf>.

Equipment and Parts List

Equipment List

- Battery monitoring system
- Battery controller
- Charger for lithium-ion battery
- 24 3.3v 20Ah lithium-ion cells
- Appropriate resistors
- Appropriate transistor

Accommodations

- Shelf space in senior lab
- Solar panels on the roof

Schedule

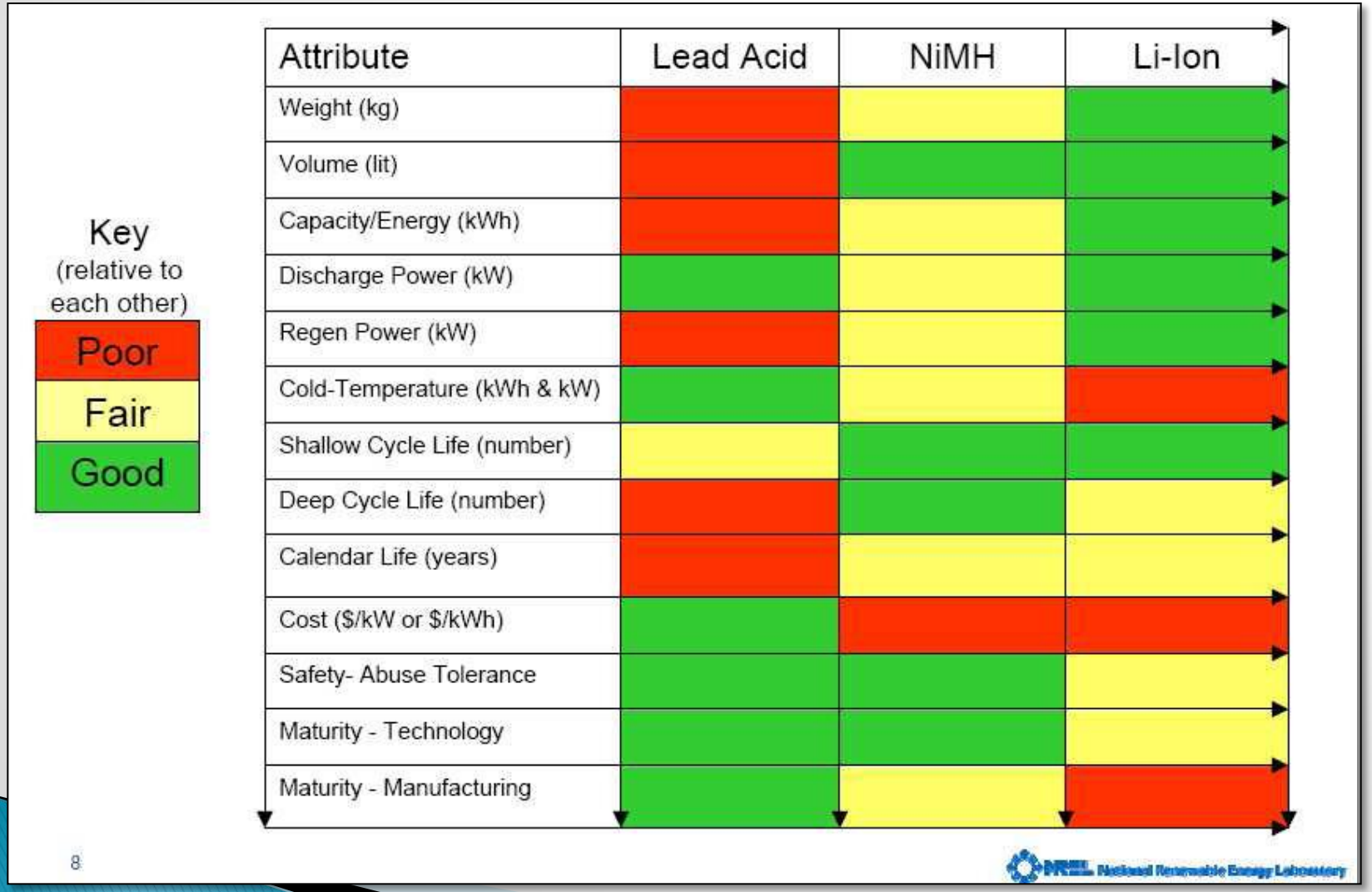
		Time		Task - Jeremy	Task - Charlie
Week	**1**	18-Jan	24-Jan	Research and modeling	Research Lab Charger
Week	**2**	25-Jan	31-Jan	Research and simulation	Research => Purchase Lab Charger
Week	**3**	1-Feb	7-Feb	Finalize Purchases	Research Charging Cicuit Topologies
Week	**4**	8-Feb	12-Feb	Design Batt. Management sys. based on chipset	Design => Test => Implement Charging Circuit
Week	**5**	15-Feb	14-Feb	Test Batt. Management sys. based on chipset	Design => Test => Implement Charging Circuit
Week	**6**	22-Feb	28-Feb	Implement batt. Management sys. Based on chipset	Purchase & Test USB interface subsystem
Week	**7**	1-Mar	7-Mar	Implement batt. Management sys. Based on chipset	Purchase & Test USB interface subsystem
Week	**8**	8-Mar	14-Mar	Charge & Discharge test on cells	Charge & Discharge test on cells
Week	**9**	15-Mar	21-Mar	Charge & Discharge test on series combinations	Charge & Discharge test on series combinations
Week	**10**	22-Mar	28-Mar	Charge & Discharge test on parallel Combinations	Charge & Discharge test on parallel Combinations
Week	**11**	29-Mar	4-Apr	Implement and test an 8 series Stack w/ Batt. Management	Implement and test an 8 series Stack w/ Batt. Management
Week	**12**	5-Apr	11-Apr	implement 2nd & 3rd 8 series stack	implement 2nd & 3rd 8 series stack
Week	**13**	12-Apr	18-Apr	implement Battery Pack & Test for Specifications	implement Battery Pack & Test for Specifications
Week	**14**	19-Apr	25-Apr	Prepare final project report	Prepare final project report
Week	**15**	26-Apr	2-May	Prepare Presentation	Prepare Presentation
Week	**16**	3-May	9-May	Presentation	Presentation
Week	**17**	10-May	16-May	Presentation	Presentation
					NOTE: Subject to Variation

Questions?

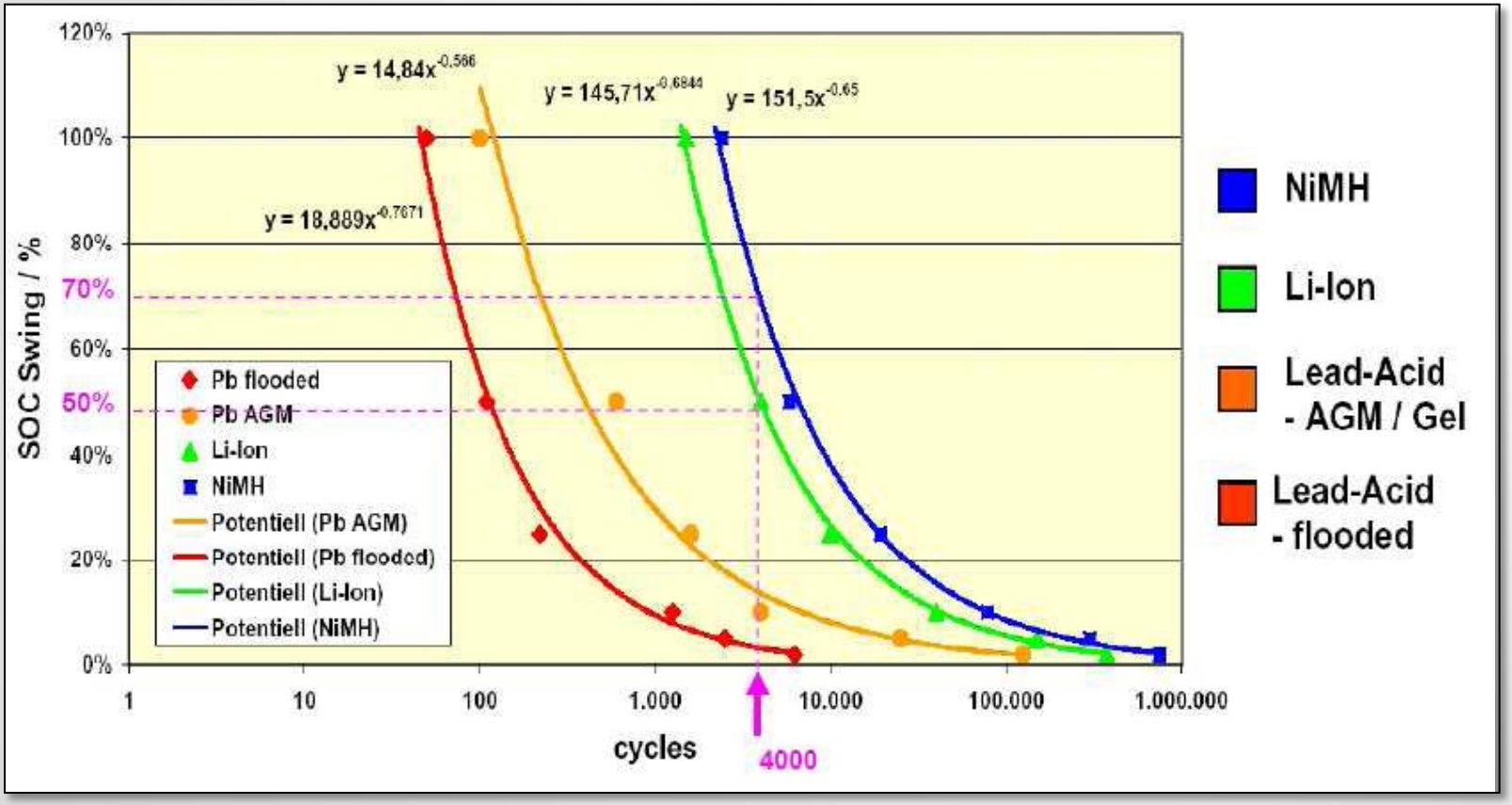
Typical Energy Storage Systems

- Lead Acid
  - 1859
- Nickel Metal Hydride
- Lithium-Ion

Battery Comparison



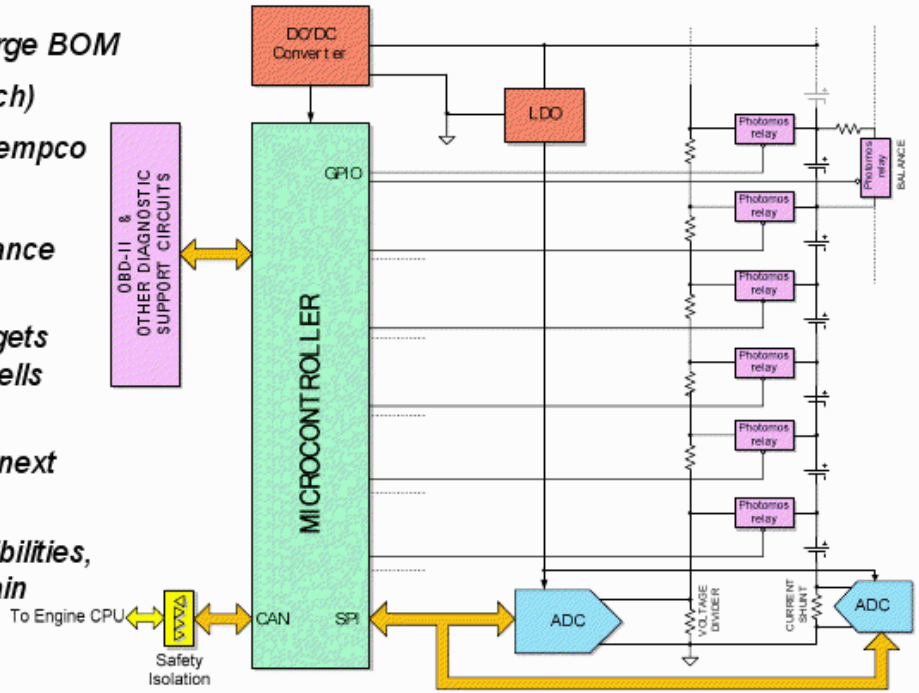
Battery Comparison (cont.)



Battery Comparison (cont.)

Battery Monitoring – the old way

- *Complex circuit, large BOM*
- *High cost ($6-$20/ch)*
- *Poor V accuracy, tempco*
- *Low bandwidth*
- *Low quality impedance measurements*
- *Low fan-in, circuit gets repeated every n cells*
- *Difficult to extend architecture to the next design*
- *Other design possibilities, but negatives remain largely the same*



Texas Instruments